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Butterley by Alfreton, Derbyshire.

DEAR SIR, *March* 21, 1842.

ON Saturday night I sent by railway a box, which I hope you wlll receive in due time, containing specimens of minerals and the iron, both cast and wrought, obtained from them. The wrought shavings sent were turned off a bar in the lathe, and shew the tenacity of the material. I sent also an additional specimen of the titanium, and I enclose a very hasty account of the quantities used in making iron at these works of the different minerals, which I hope you will be able to make out. It is in the box with the specimens.

I am, Sir, &c.

W. A. GRAHAM, Esq. JOSEPH GLYNN.
Secretary, &c. &c.

No. IV.

IMPROVEMENTS IN THE MANUFACTURE OF IRON.

The Thanks of the Society were voted to THOMAS W. BOOKER, Esq. of Melin Griffith, near Cardiff, for his Communication respecting his Patent Process of making Iron — a Model shewing the Arrangement of the Furnaces, as, also, Specimens of the Iron made by MR. BOOKER'S Process, have been placed in the Society's Repository.

SIR, *Velindra House, May* 7, 1842.

I HAVE forwarded to you this day, by the Great Western Railway from Bristol, a box containing a model and

drawing, and a paper on the manufacture of iron, which I shall feel much obliged by your laying before the Society of Arts, whose acceptance I beg of them.

The model is perfect, and to scale in all its parts. The roof of the puddling reverberatory furnace is taken off by sliding back the brass bars which lie over it, and when taken off, the shape and dimensions of the inside of the furnace are seen.

I shall feel much obliged by your informing me of the arrival of the box, and by any communication with which you may honour me on the subject.

I am, Sir, &c.

W. A. Graham, Esq.
Secretary, &c. &c.

Thos. W. Booker.

There are at present in the United Kingdom five hundred and twenty-seven blast-furnaces, capable of producing at their ordinary rate of work 42,160 tons of pig-iron weekly, or 2,192,320 tons in one year. By far the largest portion of the pig-iron produced is wrought or converted into bar-iron in this country; the cost of manufacture of bar-iron depends on a variety of circumstances and contingencies, such as the locality of the works, the application of water or steam power, the capital expended in their establishment and employed in their operations, the cost of ore and fuel, the rate of wages, the economy of management, the yield and consumption of raw materials, by means of and out of which the finished article of manufacture is produced, and the attention given to the quality of the finished production.

When we consider the vast variety of purposes to which iron is now applied, how extensively it is used in the arts and manufactures, and in the instruments of

comfort, safety, and convenience of life, it must be obvious that the quality of an article of such extensive use and consumption is of the first importance; and when we consider also the immense establishments which have grown up for its production, and the competition to which those who are engaged in its manufacture are liable, it must be alike obvious that any diminution that can be effected in the cost of its manufacture will be eagerly adopted; and without, perhaps, in every instance due regard being paid to the beneficial or injurious effects arising therefrom, upon the quality of the metal being observed.

Certain improvements, effected by the author of this paper, in the manufacture of this great staple article of national commerce, have been patented, and which he begs leave to lay before the Society of Arts. A copy of the specification of his patent is subjoined, together with a drawing and a model explanatory thereof; and to bring the results of his improvements fairly before the Society, he will only add the following summary of his plan and its effects.

The method usually, now and heretofore, adopted in the manufacture of bar-iron (where the dangerous, and, as the author thinks, reprehensible practice of puddling the crude or raw pig-iron, without the intervention of the refining process, is not adopted), is as follows: The pig-iron is thrown up on what is called the milling finery, or run into the finery in a fluid state, from the smelting or blast-furnace, and after undergoing the process of refining, it is run out into cakes or moulds, and suffered to get cold; it is then broken up into lumps of a convenient size, and thrown into the puddling reverberatory furnace, which is usually constructed with one door, and

at which only one man can work at a time. The author's improved method is detailed in his specification, plan, and model, and its effect is this—a saving of full 50 per cent in fuel, and nearly 50 per cent in metal, an immense saving of labour, and a greatly increased product of work in the puddling furnace—the usual product of a puddling furnace being from fourteen to eighteen tons in a week, while the author's will as easily produce from forty to fifty tons in a week. The author thus combines the processes of refining with puddling, and to shew the importance of preserving, and the hazard of dispensing with the refining process, he subjoins the results of analysis by M. Berthier of three samples of cinder or scoria, in one of which the remarkable fact of the presence of phosphoric acid shews how important this operation is to the purification of the iron :—

	Silica.	Protoxide of Iron.	Alumina.	Phosphoric Acid.
A Staffordshire sample	0·276 ..	0·612 ..	0 040 ..	0·072
A South Wales sample	0·368 ..	0·610 ..	0·015 ..	none
Ditto ditto	0·424 ..	0·520 ..	0·033 ..	none

THOS. W. BOOKER.

The object of Mr. Booker's invention is to simplify and accelerate the conversion of cast-iron from its crude state into malleable or wrought iron, for which purpose the refinery or furnace is adapted to the various qualities or descriptions of cast or pig-iron which it may be necessary to use, by surrounding or enclosing the hearth with blocks of cast-iron, into and through which water is allowed to flow or not as may be expedient, and as is well understood in making refinery furnaces, the blast of air being introduced through one, two, or more apertures or turies, as usual.

The refinery is connected with the reverberatory or puddling furnace, which is constructed of the requisite form and dimensions. The bottom of the body of the furnace, and the grate bars, and binding plates and bars, are formed of iron; the other parts of the furnace are constructed with fire-bricks, sand-stone, or fire-clay, as is well understood. In the neck, or near the flue of the reverberatory furnace is an aperture through which the iron, when it has become decarburetted or refined in the refinery, is introduced or run in a fluid state direct from the refining hearth into the puddling or reverberatory furnace. On each side of which reverberatory furnace a door is constructed; the door in the one side being immediately opposite to the door in the other, through which two doors the workmen perform the process of puddling in the ordinary way in which puddling is done, when working only with one door, which is the general practice.

As respects the Refining.

Having thrown up the fuel, and having, by the application of fire and blast, produced the necessary heat, a charge of 9 cwt. or thereabouts of pig or cast-iron, of the description generally used for forge purposes, is thrown on and melted down and decarburetted or refined in the ordinary way; and when the refining process is completed, the whole charge of metal is run off in a fluid state direct into the reverberatory or puddling furnace previously prepared to receive it, by having been already heated to a proper degree of temperature, and by the bottom, sides, bridge, and opening to the flue being protected in the ordinary way, by the workmen having previously thrown in a sufficient quantity of limestone and iron-cinder. The metal having been introduced into the reverberatory or

puddling furnace in a fluid state, the workmen raise, apply, and regulate, and vary the heat in the ordinary way, by feeding and moving the fire in the grate, and raising or lowering the damper on the top of the stack or flue, as circumstances require, and as is well understood; they at the same time stir and agitate the iron with bars and puddles, while the escape of the oxide of carbon in a gaseous shape takes place, and until the whole mass of iron agglutinates. The workmen then divide it into lumps or balls of a convenient size, and draw the charge from the furnace, passing the lumps to the squeezer, hammer, or rolling cylinders, or such other contrivance or machinery as are used for forging or compressing the iron.

During the process of refining the iron, by the application of heat and blast, in the open refining hearth, a considerable quantity of scoria or cinder is produced, which is tapped and run off as heretofore, as circumstances require; but it is to be observed, that during the process which the iron undergoes in the reverberatory or puddling furnace, the author does not find that any cinder need be generated or produced, and cinders and limestones are thrown in, as already described, for the protection of the various parts of the furnace exposed to the action or agitation of the fluid metal, but no cinder need be tapped or drawn off.

Mr. Aikin's Opinion.

The principal novelty in Mr. Booker's invention consists in placing the refining and the puddling furnace so near each other that the refined iron may be run in a liquid state into the puddling furnace, instead of allowing it (as is usual) to cool and become solid when let out of

the refinery, previous to its being transferred to the puddling furnace. The heat lost by the iron is thus saved, as well as the time required to bring the solid refined iron to a state of fusion.

Both the refining and puddling are to be performed, according to Mr. Booker, in the usual way; it was therefore incumbent on him to shew how it happens that while the common process of puddling produces slag, his does not.

Mr. Booker's statement that by his process a saving of full 50 per cent in fuel, and nearly 50 per cent in metal, is effected, appears to be an enormous exaggeration; the saving in the former being only (as far as appears) the fuel required to melt the refined iron. In making iron of the best quality, 31·74 cwt. of pig-iron give 26·45 refined, which is reduced to 23 in the puddling process. 8·74, therefore, is the loss which 31·74 pig suffers in becoming puddled iron. Half this loss, namely, 4·37, will represent 50 per cent of saving, and this, added to 23, makes 27·37, which is 0·92 more than the entire quantity of refined iron.

Berthier's analysis of two samples of scoriæ from South Wales, and one from Staffordshire, shewing the presence of phosphoric acid in the former and none in the latter, has no bearing on Mr. Booker's statement, that in the process of refining, the phosphoric acid is separated from the iron.

If the quality of the iron produced by Mr. Booker's process is not worse than that of iron refined and puddled in the usual method, Mr. B.'s process deserves the approbation of the Society. But I would recommend that Sir J. Guest, or some other practical iron-master, should be consulted.

Society of Arts, Adelphi,
SIR, *April* 24, 1843.

I BEG to inform you that the subject of your process in the manufacture of iron was laid before the Committee of Chemistry on the 13th instant, and I am desired to ask you, "How it happens that while the common process of puddling produces slag, yours does not?" and to obtain from you an explanation as to the "saving of full 50 per cent in fuel and nearly 50 per cent of metal."

I am, Sir, &c. &c.
THOS. W. BOOKER, Esq. FRANCIS WHISHAW,
Secretary.

Velindra House, near Cardiff,
SIR, *April* 27, 1843.

I ACCOUNT for "*the production of slag in the common puddling furnace, and its non-production in mine,*" as follows: The common puddling furnace is so constructed that the iron operated upon in it is exposed to a very rapid draught or current of air, which rushes in at the grate at the back of the furnace, and passes off through the body and into the flue and stack at the head thereof. This draught is so great as to oxidize the iron, and transform a great portion of it into slag or scoria during the process of puddling, which process, moreover, is effected so slowly, that the charge of iron, consisting of from 3½ cwt. to 4½ cwt. is exposed to the heat and draughts in the puddling furnace during the space of full an hour and a half.

My puddling furnace is so constructed, that the draught or current of air admitted at the grate is broken, and its oxidizing effects upon the surface of the iron while fluid, and upon the fibrous particles as they cohere,

after the oxide of carbon has been expelled, are entirely neutralised. That portion, therefore, of the charge which in the common puddling furnace is converted into slag or cinder, in mine is not wasted or oxidised, but remains, and is converted into pure malleable iron.

In the common puddling furnace, too, the charge, either of refined metal from the refinery, or of raw pig-iron from the blast-furnace, as the case may be, is placed, in cold lumps, in the puddling furnace. In mine, the charge of iron, consisting of 9 cwt. is run off (after undergoing the process of refining) direct, and in a fluid state, from the refinery into the puddling furnace, where it is acted upon by the heat, and operated upon by the workmen at once, and where the whole charge thus run off is converted from refined cast-iron into wrought or malleable iron within the space of (at the very outside) three-quarters of an hour, and it is generally done within the half hour.

"*The saving of fuel*" is accounted for thus: In the common puddling furnace not more than 4½ cwt. of metal is admitted at one time, and this in a solid cold state. In mine, double the quantity is admitted, and that in a melted and fluid state. It is obvious that the time, fuel, and labour necessary for *melting* the iron are saved, and that double the quantity of iron is converted from a cast into a malleable state within half the same space of time.

I send you in a box by Great Western Railway (the carriage of which is paid) samples of iron (smelted from the ore, and manufactured at the works of my firm, Richard Blakemore, M.P. and Co.), refined and puddled by my process, and afterwards manufactured in the ordinary way with pit coal. The samples consist of a rough puddled or No. 1 bar, in the state in which it

comes from the machinery which compresses and rolls it immediately after it has been refined and puddled in my furnace; also of a finished No. 2 bar, in the ordinary state of merchant bar-iron; and two specimens of No. 3 bolt-cable or rivet-iron. The whole have been bent and twisted, as you will see them, while perfectly cold; and one of the bolts has been notched, in order to break it, so as to shew its fibrous texture. *The whole are produced entirely from iron smelted with hot blast.*

I hope and trust the Society of Arts will take up the question, practically and scientifically, of the relative qualities and properties of iron smelted in the hot and cold blast, and of that also produced with the various kinds of vegetable and mineral fuel, and from the calcareous and argillaceous ores. Considering the purposes to which iron is now so extensively applied, and how much the safety and convenience of the public and of individuals are hazarded by its various uses; and considering, also, the temptations which the existing competitions in the iron trade hold out to its cheap production and manufacture, without any reference or regard to the essential properties which iron ought to possess, there are few subjects, as it appears to me, of greater importance, and none on which the attention of the Society of Arts of Great Britain can be bestowed with greater public and national advantage.

I shall at all times be happy to communicate to the Society any information in my power.

I am, Sir, &c.

Francis Whishaw, Esq.
Society of Arts.

Thos. W. Booker.